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INFLUENCE OF FOREST STAND AND GROUND COVER VEGETATION ON SOIL FORMATION

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In seeking to find quantitative relations between soils and the soil-forming factors (see e.g. LÅG 1958 b), an endeavour has been made to isolate the effects of the individual factors, or groups of factors. While considering the influence of the vegetation upon the soil, it was of interest also to investigate more closely the effects of the species in the forest stand and the ground vegetation, respectively. When the vegetation is considered as a soil-forming factor, the interaction between plants and soils has of course to be taken into account. The vegetation not only influences the soil formation, but is also to a marked degree a function of the properties of the soil.

A comparison of the different soil-forming factors has been carried out on what might be called the principle of counterbalance. An attempt has been made to produce material with variations in only one factor, or groups of factors. When a numerical material for two or more factors, or groups of factors, has been obtained in this way, their effects may be compared. Some of the factors are easily characterized numerically. For others, e.g. vegetation, it has been suggested to adopt scales denoting the order of rank (LÅG 1958 b, p. 281). In investigations on the Norwegian forest soils, changes in the proportional areas of brown earth to podzol have been used as a kind of measure of the effect of the variation within the soil-forming factors.

The numerical material available has been collected in cooperation with our National Forest Survey. Financial support has been received from the Agricultural Research Council of

Norway for the further treatment of the material. During the years 1954-57 from 6000 to 13000 plots were surveyed annually. Each surveyed plot had a diameter of 10 m, except in 1957 when it was 11.28 m. Tree species, ground cover vegetation, main type of profile and some other soil properties were recorded for each plot. The forest stands were grouped into: forest of Norway spruce; forest of Scots pine; mixed coniferous forest; broad-leaved forest, and other types of mixed forest. The broad-leaved forest was to some extent subdivided further. The ground vegetation was divided into: 1. forest ground rich in grasses and herbs; 2. mosses with some herbs; 3. *Vaccinium myrtillus* with *Dryopteris*; 4. *Vaccinium myrtillus* without *Dryopteris*; 5. *Vaccinium vitis-idaea*; 6. *Calluna vulgaris*; 7. lichens, and 8. waterlogged forest ground. Each of these types of vegetation were further divided into two subgroups, according to whether or not there occurred *Sphagnum*. In addition to the 8 vegetation types two new types were instituted in the last year.

As a rule only a few types of ground cover vegetation are common under each individual forest group mentioned above. In a numerical material of this order, however, some surveyed plots will have combinations of tree species and ground vegetation, that are not common. It is, therefore, possible to carry out relatively comprehensive comparisons of tree species and ground vegetation as soil-forming factors.

In comparing the numerical material, collected in 1955 in Agder (LÅG 1957), and in 1956 in Sör-Tröndelag (LÅG 1958 a) the proportional area of brown earth to podzol (see Tables 1 and 2) showed a closer relation to the variation in ground vegetation than to the variation in tree species in the forest stand. As stated above the vegetation is not an « independent variable », but is dependent among other things on the properties of the soils. It is, therefore, difficult to distinguish between cause and effect in the relationship between plant and soil formation. It can be said, however, that in the Norwegian forests there seems to be a closer relationship between the ground cover vegetation and the development of the profile than between the tree species and the development of the profile.

Forest ground rich in *Vaccinium vitis-idaea*, *Calluna vulgaris*, or lichens, covered only, or nearly only, podzol.

TABLE 1. — *Ratio of number of plots with brown earth to that of podzol in different kinds of forest and with different ground vegetation. Agder counties.*

Forest of Norway spruce:	Brown earth: Podzol
Forest ground rich in grasses and herbs	1: 0.57
Forest ground rich in mosses and with some herbs	1: 1.15
Forest ground rich in Vaccinium myrtillus with Dryopteris	1: 1.53
Forest ground rich in Vaccinium myrtillus without Dryopteris	1:10.4
Forest of Scots pine:	
Forest ground rich in grasses and herbs	1: 1.00
Forest ground rich in mosses and with some herbs	1: 3.33
Forest ground rich in Vaccinium myrtillus with Dryopteris	1: 4.79
Forest ground rich in Vaccinium myrtillus without Dryopteris	1:29.8
Broad-leaved forest:	
Forest ground rich in grasses and herbs	1:0.57
Forest ground rich in mosses and with some herbs	1:0.70
Forest ground rich in Vaccinium myrtillus with Dryopteris	1:2.83
Forest ground rich in Vaccinium myrtillus without Dryopteris	1:6.97

TABLE 2. — *Ratio of number of plots with brown earth to that of podzol in different kinds of forest and with different ground vegetation. Sör-Tröndelag county.*

Forest of Norway spruce:	Brown earth: Podzol
Forest ground rich in grasses and herbs	1: 0.20
Forest ground rich in mosses and with some herbs	1: 0.34
Forest ground rich in Vaccinium myrtillus with Dryopteris	1: 3.66
Forest ground rich in Vaccinium myrtillus without Dryopteris	1:22.9
Forest of Scots pine:	
Forest ground rich in grasses and herbs	1: 0.38
Forest ground rich in mosses and with some herbs	1: 1.25
Forest ground rich in Vaccinium myrtillus with Dryopteris	1: 6.29
Forest ground rich in Vaccinium myrtillus without Dryopteris	1:24.7
Broad-leaved forest:	
Forest ground rich in grasses and herbs	1: 0.20
Forest ground rich in mosses and with some herbs	1: 0.04
Forest ground rich in Vaccinium myrtillus with Dryopteris	1: 3.25
Forest ground rich in Vaccinium myrtillus without Dryopteris	1:20.0

A comparison was carried out between soil formation under ground vegetation with and without patches of *Sphagnum*. Where *Sphagnum* was present the frequency of podzol was somewhat higher than where this moss was lacking. The difference was especially marked in Sör-Tröndelag. In Agder, where the climate is somewhat milder, the difference was less marked. When the numerical material was treated collectively, podzol was found to be approximately 4 times as frequent under vegetation with *Sphagnum* as under vegetation without *Sphagnum* in Sör-Tröndelag. For Agder the corresponding numerical values were a little less than 2.

The collection and treatment of the numerical material for an appraisal of the relation between vegetation and soil formation in Norway are being continued. It is to be hoped, therefore, that it will be possible to carry out more detailed comparisons later.

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SUMMARY

Investigations carried out in Norwegian forests have indicated that the soil formation is closer correlated with the nature of ground cover vegetation than with the composition of main forest stand. A progressive increase in the frequency of occurrence of podzolized soils is indicated by the following series of ground cover vegetation: 1. forest ground rich in grasses and herbs, 2. forest ground rich in mosses and with some herbs, 3. forest ground rich in *Vaccinium myrtillus* with *Dryopteris*, and 4. forest ground rich in *Vaccinium myrtillus* without *Dryopteris*. In other words, brown earth is much more frequent under grasses and herbs than under *Vaccinium myrtillus*. Under vegetation dominated by 5. *Vaccinium vitis-idaea*, 6. *Calluna vulgaris*, or 7. reindeer moss and other lichens had only, or nearly only, podzol. *Sphagnum* seems to favour podzolization rather than the formation of brown earth.

RÉSUMÉ

Des recherches conduites dans des forêts norvégiennes ont indiqué que la formation du sol est plus étroitement liée à la nature du tapis végétal qu'à la composition de sa végétation principale d'arbres. Une augmentation progressive dans la fréquence du sol podsolisé présent est donnée par la série suivante de couverture végétale du sol forestal: 1. sol forestal riche en herbes, 2. sol forestal riche en nousses et aves quelques herbes, 3. sol forestal riche en *Vaccinium myrtillus* avec *Dryopteris*, et 4. sol forestal riche en *Vaccinium myrtillus* sans *Dryopteris*. C'est-à-dire, la terre brune est bien plus fréquente sous les herbes que sous *Vaccinium myrtillus*. Sous une végétation dominée par 5. *Vaccinium vitis idaea*, 6. *Calluna vulgaris*, ou 7. *Cladonia rangiferina* et autres lichens se trouve seulement, ou presque seulement, du podsol. *Sphagnum* semble favoriser plutôt la podsolisation que la formation de terre brune.

ZUSAMMENFASSUNG

Untersuchungen in norwegischen Wäldern weisen darauf hin, dass die Bildung des Bodens im engeren Zusammenhang mit der Natur der Pflanzendecke des Bodens selbst als mit der Zusammensetzung des Hauptbestandes des Waldes steht. Eine fortschreitende Zunahme in der Häufigkeit des Vorkommens podzolisierter Böden wurde durch die folgende Reihenfolge von Pflanzendecken aufgewiesen: 1. Waldboden mit üppigem Gras- und Kräuterwuchs, 2. Waldboden mit üppiger Moosdecke und einigen Kräutern, 3. Waldboden reich an *Vaccinium myrtillus* mit *Dryopteris*, 4. Waldboden reich an *Vaccinium myrtillus* ohne *Dryopteris*. Mit anderen Worten, braune Erde tritt unter Gras und Kräutern viel häufiger auf als unter *Vaccinium myrtillus*. Unter einer Pflanzendecke, in der 5. *Vaccinium vitis-idaea*, 6. *Calluna vulgaris* oder 7. *Cladonia rangiferina* und andere Flechten vorherrschen, befand sich ausschliesslich, oder fast ausschliesslich, Podzol. *Sphagnum* scheint eher die podzolisierung als die Bildung Braunerde zu fördern.

RESUMEN

Rebuscas efectuadas en bosques de Norvegia han indicado que la formación del suelo está en relación más intima con la natura de la vegetación de cobertura del suelo que con la composición de la vegetación arborea principal del bosque. Un aumento progresivo de la frecuencia de suelos podsolizados es indicado por la serie siguiente de vegetaciones de cobertura del suelo: 1. suelo del bosque rico de hierbas, 2. suelo del bosque rico de musgos y con algunas hierbas, 3. suelo del bosque rico de *Vaccinum myrtillus* con *Dryopteris*, y 4. suelo del bosque rico de *Vaccinium myrtillus* sin *Dryopteris*. En otras palabras, la tierra morena es mucho mas frecuente bajo hierbas

que bajo *Vaccinium myrtillus*. Bajo vegetación dominada por 5. *Vaccinium vitis-idaea*, 6. *Calluna vulgaris*, o 7. *Cladonia rangiferina* y otros liquenes hay solo o cuasi solo podsol. Parese que el *Sphagnum* favorezca la podsolización más bien que la formación de tierra morena.

RIASSUNTO

Ricerche eseguite nelle foreste norvegesi hanno portato a risultati indicanti che la formazione del terreno è in piú stretta correlazione con la natura della cotica erbosa che non con la composizione della sua vegetazione arborea principale. Un progressivo aumento nella frequenza con cui sono presenti terreni podzolizzati viene indicato dalla seguente serie di cotiche erbose: 1. foresta ricca di erbe e piante foraggere; 2. terreno boschivo ricco di muschio con qualche erba; 3. terreno boschivo ricco di *Vaccinium myrtillus* con *Dryopteris*; 4.terreno boschivo ricco di *Vaccinium myrtillus* senza *Dryopteris*. In altri termini, la terra bruna è molto piú frequente sotto erbe e piante foraggere che sotto *Vaccinium myrtillus*. Sotto una vegetazione dominata da 5. *Vaccinium vitis-idaea*; 6. *Calluna vulgaris*, oppure 7. *Cladonia rangiferina* o altri licheni si trovava solamente, o quasi esclusivamente, podzol. *Sphagnum* sembra favorire piuttosto la podzolizzazione che la formazione di terra bruna.

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